

## ABSTRACT OF THE DISCLOSURE

A composite  $\alpha$ -Ta/ graded tantalum nitride /TaN barrier layer is formed in Cu interconnects with a structure designed for improved wafer-to-wafer uniformity, electromigration resistance and reliability, reduced contact resistance, and increased process margin. Embodiments include a dual damascene structure in a low-k interlayer dielectric comprising Cu and a composite barrier layer comprising an initial layer of TaN on the low-k material, a graded layer of tantalum nitride on the initial TaN layer and a continuous  $\alpha$ -Ta layer on the graded tantalum nitride layer. Embodiments include forming the initial TaN layer at a thickness sufficient to ensure deposition of  $\alpha$ -Ta, e.g., as at a thickness of about 50 Å to about 100 Å. Embodiments include composite barrier layers having a thickness ratio of  $\alpha$ -Ta and graded tantalum nitride: initial TaN of about 2.5:1 to about 3.5:1 for improved electromigration resistance and wafer-to-wafer uniformity.